the well-established convective outflow mechanism for forming subvisible cirrus clouds. The figure shows the back trajectories on the 380-kelvin isentropic surface from 16 points along the flight track on February 13, 1996. Subvisible cirrus clouds were observed near the tropopause at north latitude 5 and 10 degrees. Most of the parcels have originated in the western Pacific where convection is prevalent, have been transported northward and eastward and warmed as a result of adiabatic descent, and then cooled by adiabatic ascent as they travel southward. The warming is about 5 degrees, implying a doubling of the saturation mixing ratio. This means that any cloud particles left after convective outflow are unlikely to have survived. Thus, the observed thin cirrus clouds are almost certainly a result of recondensation in response to cooling.

A technique for forecasting air masses that have been convectively influenced—which uses trajectory analysis combined with meteorological satellite data—has also been developed. This, along with satellite image display tools that have been developed, will be used in future missions, such as the examination of the North Atlantic flight corridor for evidence of pollution by nitrogen oxides and their effects on upper tropospheric ozone. The back trajectories combined with meteorological satellite data have already been used to evaluate the effect of convection on tropospheric measurements of hydroxyl radical (OH) by the ER-2 during the Stratospheric Tracers Atmospheric Transport Study.

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Convectively Generated Gravity Waves

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Convectively generated gravity waves are one of the major uncertainties in the momentum budget of the stratosphere. Recent momentum budget studies have shown that several phenomena, including the polar night jet in the Antarctic winter stratosphere, the zonal winds in the summer midlatitude stratosphere, and the quasibiennial oscillation, cannot be explained by topography gravity-wave forcing and planetary-wave forcing alone. It is clear that convection generates significant gravity-wave energy; the problem is that convection is a sufficiently complex phenomena, and the data sufficiently sparse, that a clear picture of the amplitudes and phase speeds of convectively generated gravity waves has yet to emerge.

Progress has been made in two areas. First, an analysis was made of a case study of gravity waves generated by convective systems, since recent theoretical and modeling work suggests that the simple "transient-mountain-at-the-tropopause" conceptual model can explain only part of the mesoscale gravity-wave variance. Evidence was found for waves with horizontal wavelengths of about 50 kilometers and vertical wavelengths of about 5–10 kilometers. Also found was evidence of inertia-gravity waves with horizontal wavelengths of 1000 kilometers, which is consistent with studies that inferred horizontal wavelengths using vertical profiles and inertia-gravity wave dispersion relationships.

Second, the study team has participated in an international group that is doing some preliminary planning for an international convective gravity-wave experiment using ER-2 aircraft. One of the products of this group is a white paper describing the motivation, participation, and venue of the experiment.

In addition, the team has arranged for some rapid satellite scans of convective systems being overflown by the ER-2 during the Photochemistry of Ozone Loss in the Arctic Region in Summer campaign. The purpose is to isolate some of the high-frequency forcing of gravity waves in the stratosphere. Joan Alexander, University of Washington, collaborated with the study team on this project.

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